AL/DO-TP-1993-0025

ARMSTRONG LABORATORY

AUTOMATED DATA COLLECTION SYSTEM FOR THE TCM3 TRANSCUTANEOUS pO_2/pCO_2 MONITORING SYSTEM

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240-3453

August 1993

Final Technical Paper for Period January 1993 - June 1993

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BROOKS AIR FORCE BASE, TEXAS

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This paper has been reviewed and is approved for publication.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 1993	Final January 1993 - June 1993

4. TITLE AND SUBTITLE

Automated Data Collection System for the TCM3 Transcutaneous pO_2/pCO_2 Monitoring System

5. FUNDING NUMBERS

6. AUTHOR(S)

Roxanne Constable

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Armstrong Laboratory (AFMC)
Operations and Support Directorate
Technical Operations Division
2404 E Drive, Suite 1
Brooks Air Force Base, TX 78235-5112

8. PERFORMING ORGANIZATION REPORT NUMBER

AL/DO-TP-1993-0025

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Hyperbaric Medicine Division of the Armstrong Laboratory (AL/AOHP) routinely uses the TCM3 Transcutaneous system for monitoring of patients and during research protocols. The monitor is used to measure the amount of oxygen/carbon dioxide at the skin surface. Up to 3 monitors may be utilized, and all data must be written down by hand at some interval. This method requires an individual to be watching the monitors at all times. If any further data analysis is to be performed, then the data must be entered into a computer by hand, or the manipulations are performed on paper. The purpose of this technical paper is to describe a data acquisition system designed to automate the collection and analysis of information processed by the TCM3 transcutaneous monitor. The hardware portion of the system is designed around a Macintosh II computer, and the software was written using LabVIEW 2.

14. SUBJECT TERMS

Data acquisition
LabVIEW
Medical Monitors

15. NUMBER OF PAGES

22

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

AUTOMATED DATA COLLECTION SYSTEM FOR THE TCM3 TRANSCUTANEOUS pO_2/pCO_2 MONITORING SYSTEM

INTRODUCTION

The Hyperbaric Medicine Division of the Armstrong Laboratory (AL/AOHP) routinely uses the TCM3 Transcutaneous system for monitoring of patients and during research protocols. The device is used to measure the amount of oxygen/carbon dioxide at the skin surface. Up to 3 monitors are utilized, and all data must be written down by hand at some interval. This method requires an individual to be watching the monitors at all times. This paper describes a simple system to automate the collection and analysis of this information. The system described here could easily be adapted to be used at any facility using this type of monitoring system.

METHODS

Hardware

There was an urgent need for the data acquisition system; therefore, the major goal was to design around equipment available in-house.

The TCM3 monitor provides output in analog and digital (RS-232) formats. To use the digital output, a separate serial port is required for each monitor connected to the data acquisition system. Most computers do not have 3 serial ports readily available, as they are also used to communicate with the mouse, printers, scanners, etc. Therefore, utilization of the analog output of the monitors was determined to be the best solution. An analog data acquisition board and a Macintosh computer of sufficient capability was available for use, resulting in the decision to proceed on this platform.

The hardware setup consisted of a Macintosh II computer with 10 Mb of memory, and a National Instruments NB-MIO-16H multi-purpose data acquisition board. This board has sufficient on-board gain for the analog signal sent by the TCM3; therefore, we did not need to amplify the signal before converting. Used in the single-ended mode, the board supplies 16 analog input channels. Only 3 channels were required to implement this system. Figure 1 is a block diagram describing the computer interface hardware connections. All interface cables were built in-house.

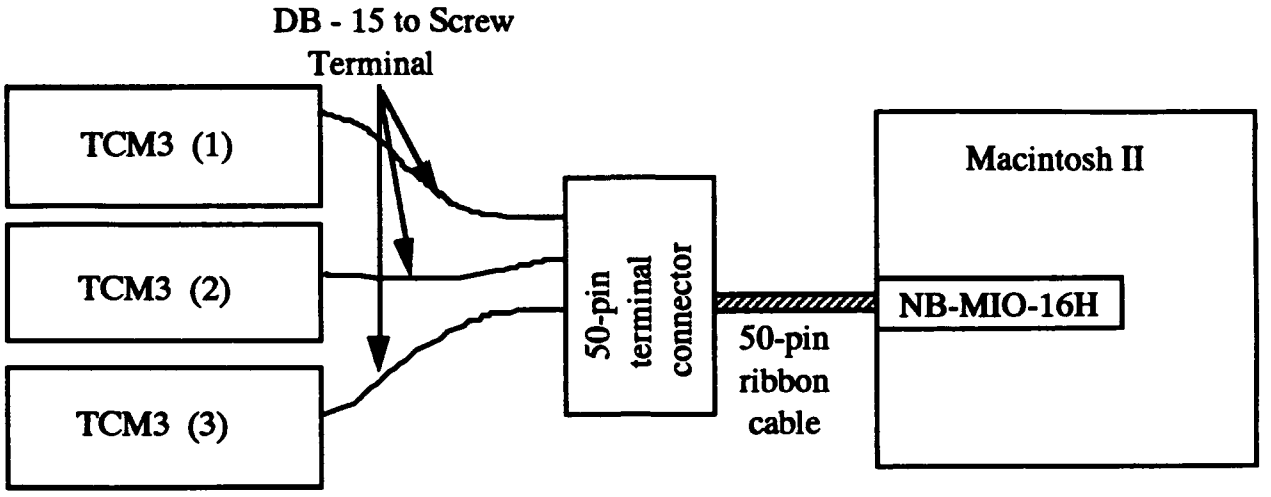


Figure 1. Cabling diagram for the TCM3 automated data collection system.

The cabling diagram included in the *Transcutaneous pO_2/pCO_2 Monitoring System User's Handbook* (1) was used. After extensive testing, we found that the data provided was not sufficient to build the cable correctly. Figure 2 shows the instructions provided and the additional information required to properly construct the cable. The cable must be plugged in before the device is turned on. If the cable is not plugged in when switched on, the device automatically defaults to digital output mode, and there is no way to change it back to the analog output mode without switching the power off, then back on.

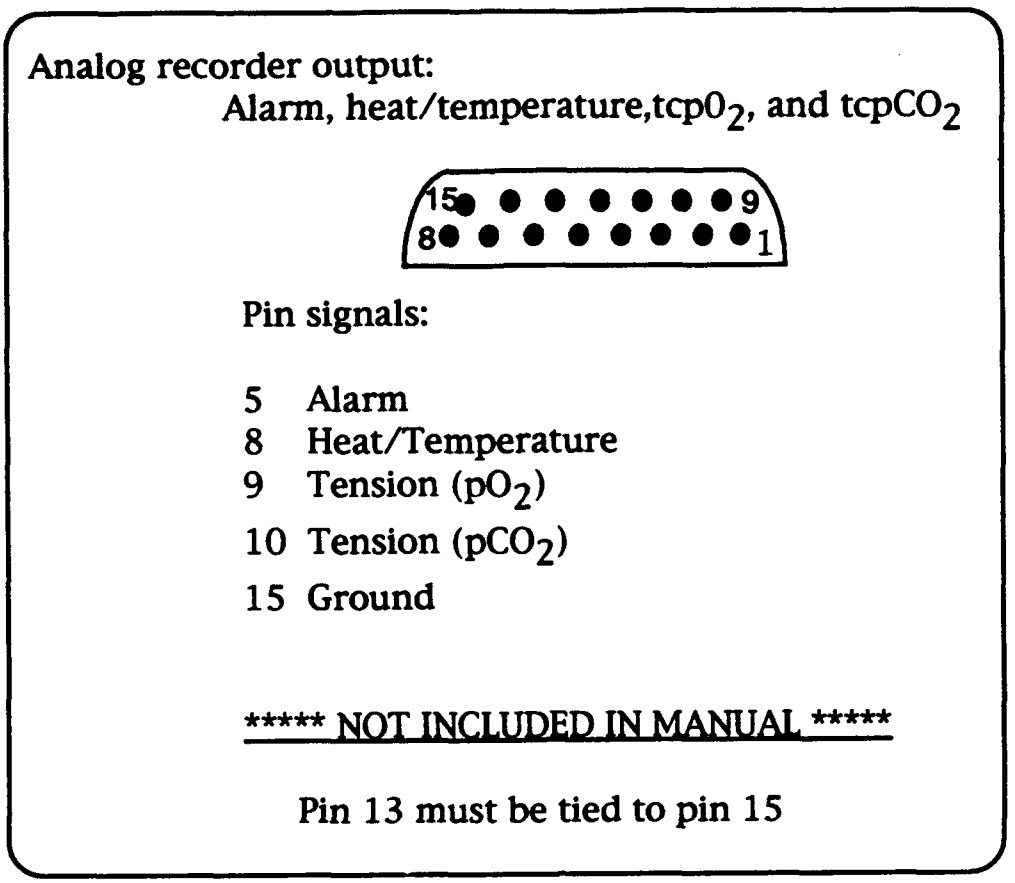


Figure 2. Cable pin-outs and other necessary cabling information.

Software

The software was written using LabVIEW 2 (2), an interactive programming environment developed by National Instruments. It is available for MS-DOS or Macintosh computer systems. This programming environment provides the drivers for the data acquisition boards, as well as tools to make the user interface easy to operate and interpret. The basic unit of LabVIEW is the Virtual Instrument (VI). A VI is a complete program which behaves as an instrument. Each instrument has its own front panel which consists of switches, knobs, and indicators. This panel serves as the interface between the user and the program, and can be made to nearly duplicate the operating panel of the actual instrument. Behind each front panel is a block diagram, which serves the same function of textual code in conventional languages. The block diagram is where other VI's and basic functions have been "wired" together to build the program. Each subVI (a VI used as a subroutine) has its own front panel of inputs and indicators which are controlled or read by the block diagram.

One of LabVIEW's major advantages is the ease with which VI's can be reused and/or adapted for use in many varied applications. LabVIEW forces the developer to use modular programming techniques

and provides an easy method for program documentation. The intuitiveness of LabVIEW VI's and their self-documentation features allow any user to adapt the VI for their application.

There were two separate programs written for this project. The first program (TCPO2MMON) reads in the data at user defined intervals, then plots the data on the screen and stores the data to disk at a user defined interval. The second program (Read and Graph) is used to review the data after the study has been completed, or the patient has completed his/her treatment. The program reads back the stored data and plots it on the computer screen. Although not currently implemented, LabVIEW supplies a wide range of data analysis routines which could be used to further analyze the data.

TCPO2MMON

The front panel for this program is shown in Figure 3. The system uses a color monitor which allows the indicators and trend lines to be color-coded. This feature is not evident in this figure. The diagram is included in the Appendix. Before starting the program, the user inputs how often data is to be collected, how often data is to be saved to the hard disk, and whether the devices are operating on full or half scale. The user then starts the program.

After start-up, the user is prompted to enter a filename under which to store the data. Following this prompt, another panel is displayed in which the user can enter subject data and other pertinent experimental data. This material is appended to the data file for later retrieval. Data collection begins after this information has been entered.

At the sampling interval, 10 samples are collected and averaged for each channel and returned as the data point. This feature helps to reduce noise which may be introduced, especially as the input signal voltage levels are low and thereby easily contaminated. The software is written to collect all of the data available from the TCM3 monitors. However, currently only the chest, leg, and foot oxygen data is being stored and displayed. The digital display is updated at the rate data is collected, and then the data is used to update the chart. This chart provides the researcher a graphical, real-time display of the data. The data is stored to the hard disk in ASCII text format. This feature allows the file to be opened by any spreadsheet, statistical, or word processing package.

At the end of the experiment, the user uses the mouse to "click" on the test complete switch. This feature suspends the data acquisition, and closes the data file. At this time, the user can begin the process over again using a different file name.

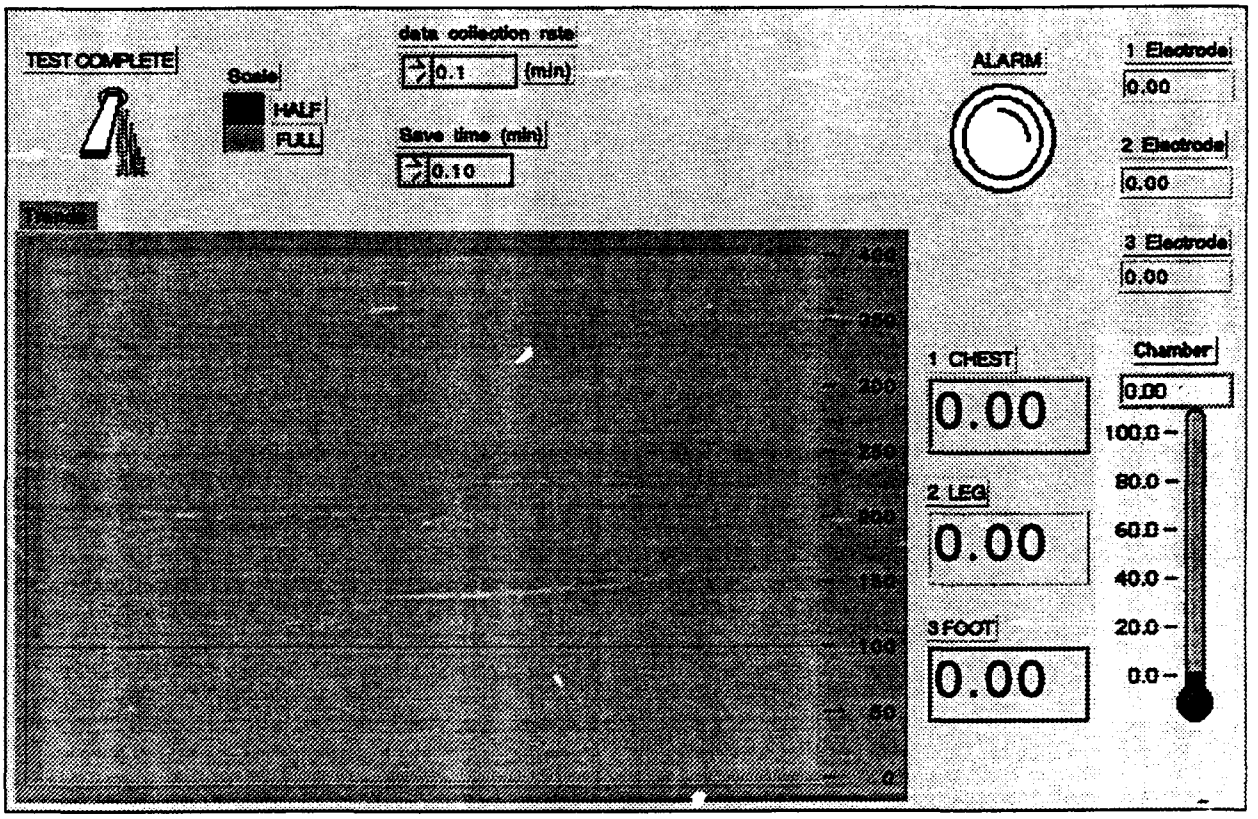


Figure 3. TCPO2MMON Front Panel.

Read & Graph

The front panel for this program is shown in Figure 4. The system uses a color monitor which allows the indicators and trend lines to be color-coded. This feature is not evident in this figure. The diagram is included in the Appendix.

After the program begins, the user is prompted for the name of the data file to read. Once this is entered, the data file is read in and displayed both numerically and graphically. The graph is expressed in terms of data v. time, allowing the user to analyze trends, slopes, etc.

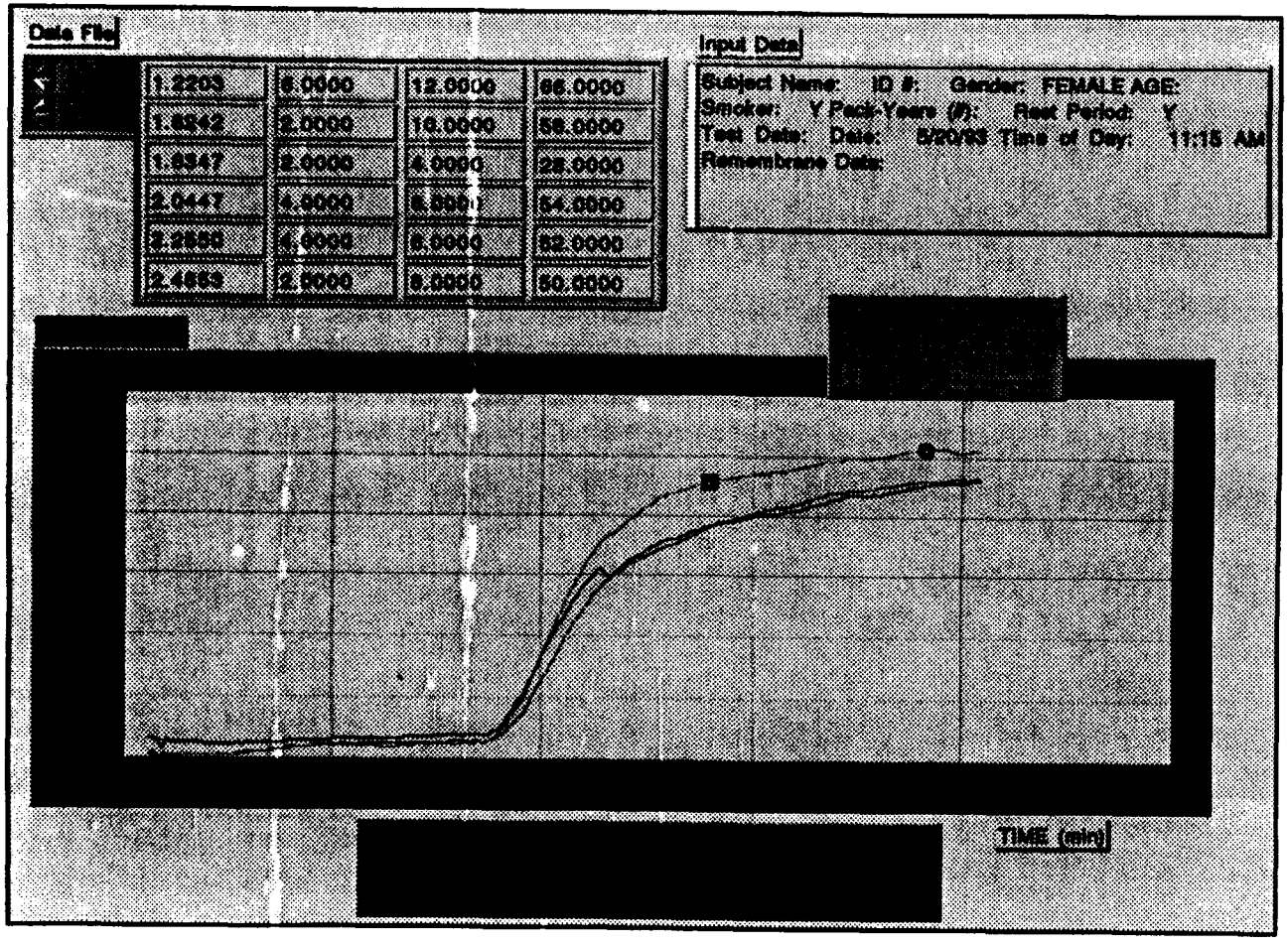


Figure 4. READ & GRAPH Front Panel.

RESULTS AND CONCLUSIONS

Using readily available tools, a powerful and user-friendly data acquisition system was developed for use by the Hyperbaric Medicine Division. The system reduces the need for additional personnel to be present during a study, and reduces the need for data to be recorded manually and then manually entered into a computer for analysis. The data is available in a convenient spreadsheet format which can then be printed out and kept with the patient's file for later reference.

With the availability of personal computers today, and software tools such as LabVIEW, data acquisition is no longer the difficult task that it was several years ago. Although not all problems can be solved as easily as this one, the payoff to the investigator can be significant time savings later in terms of recording, retrieving, and analyzing the data, even if the initial investment in time and equipment appears to be great.

REFERENCES

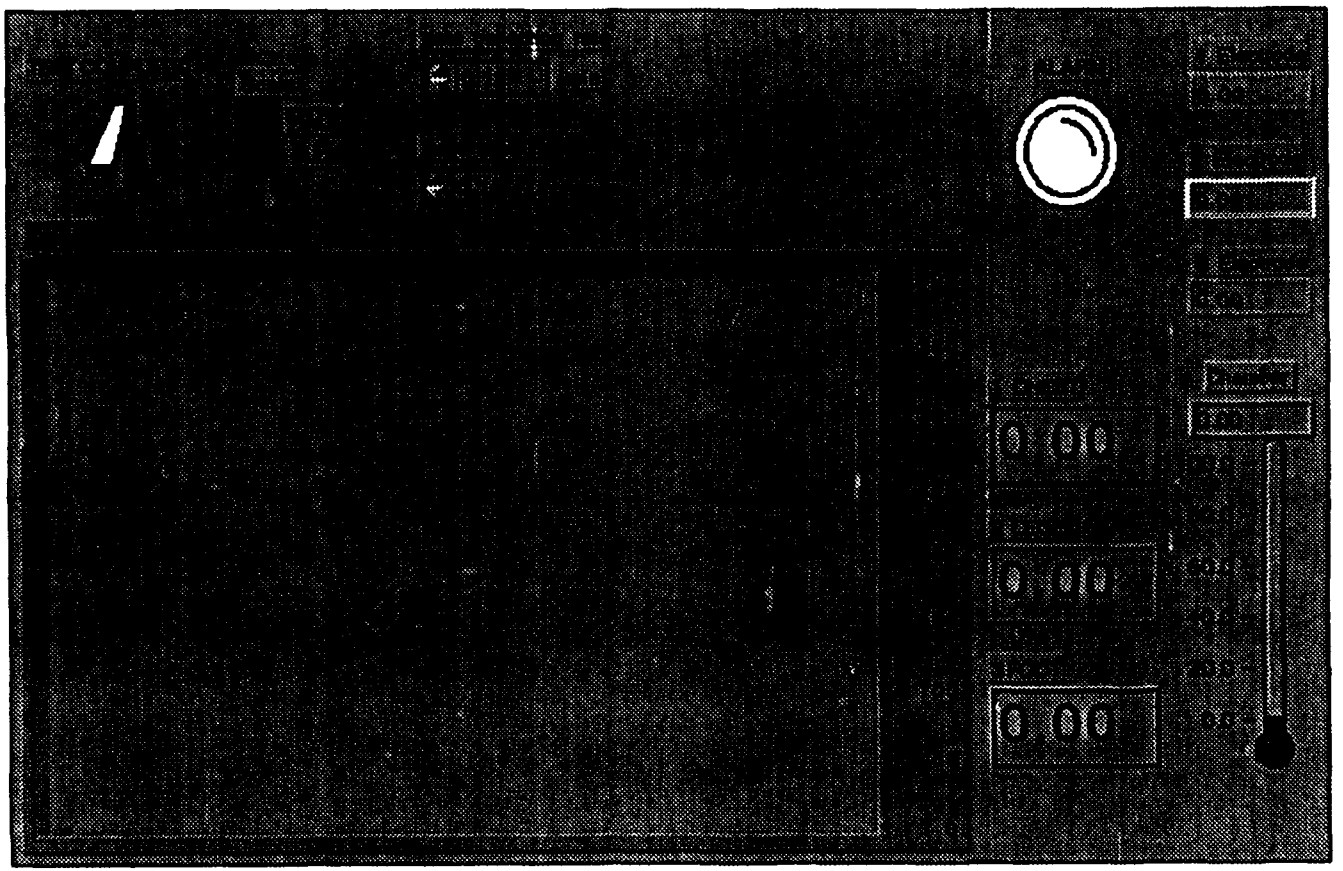
1. *Transcutaneous pO_2/pCO_2 Monitoring System User's Handbook*, Radiometer/Copenhagen, Edition D, January 1990.

2. *LabVIEW 2 User Manual*, National Instruments, Austin TX, July 1992.

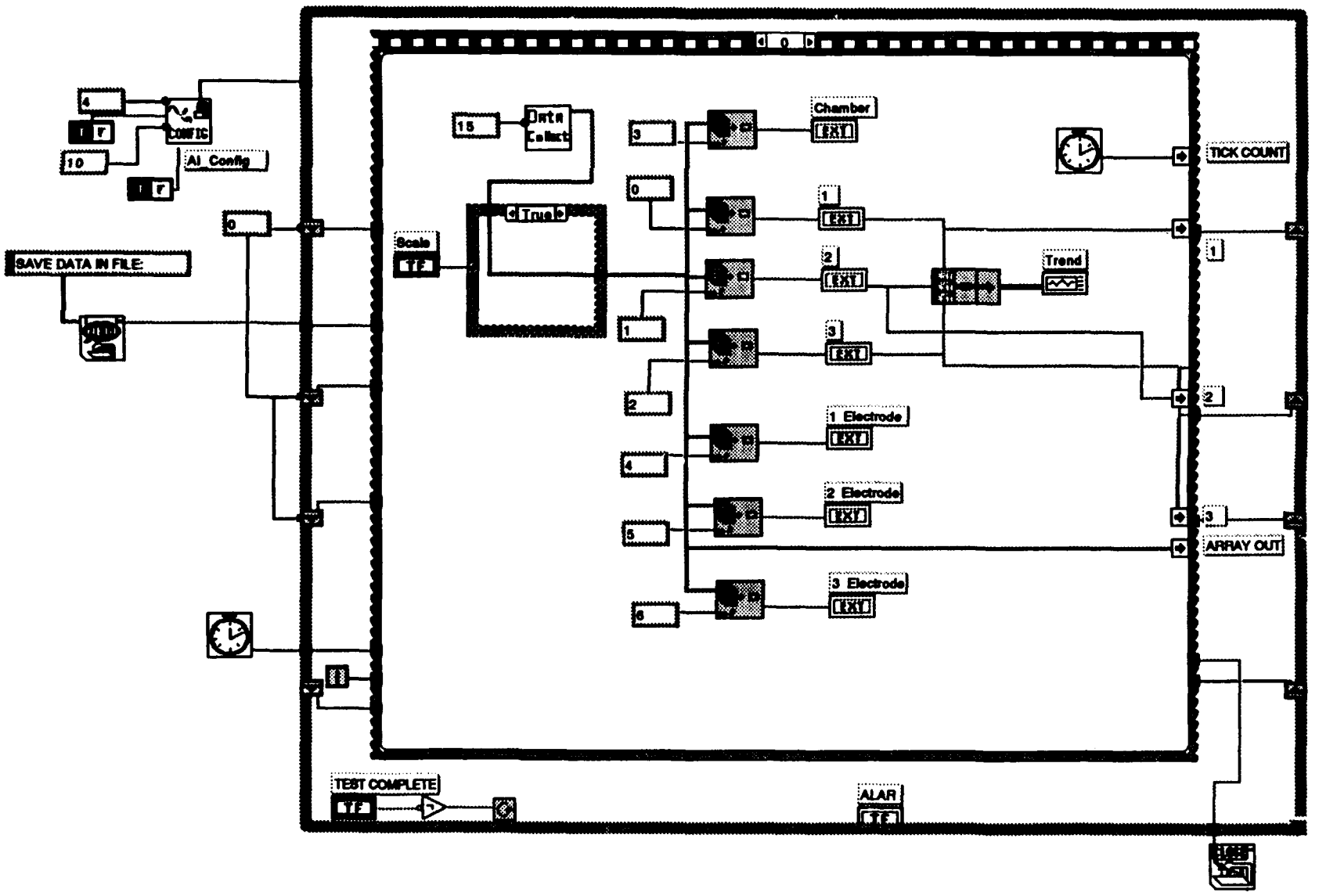
APPENDIX

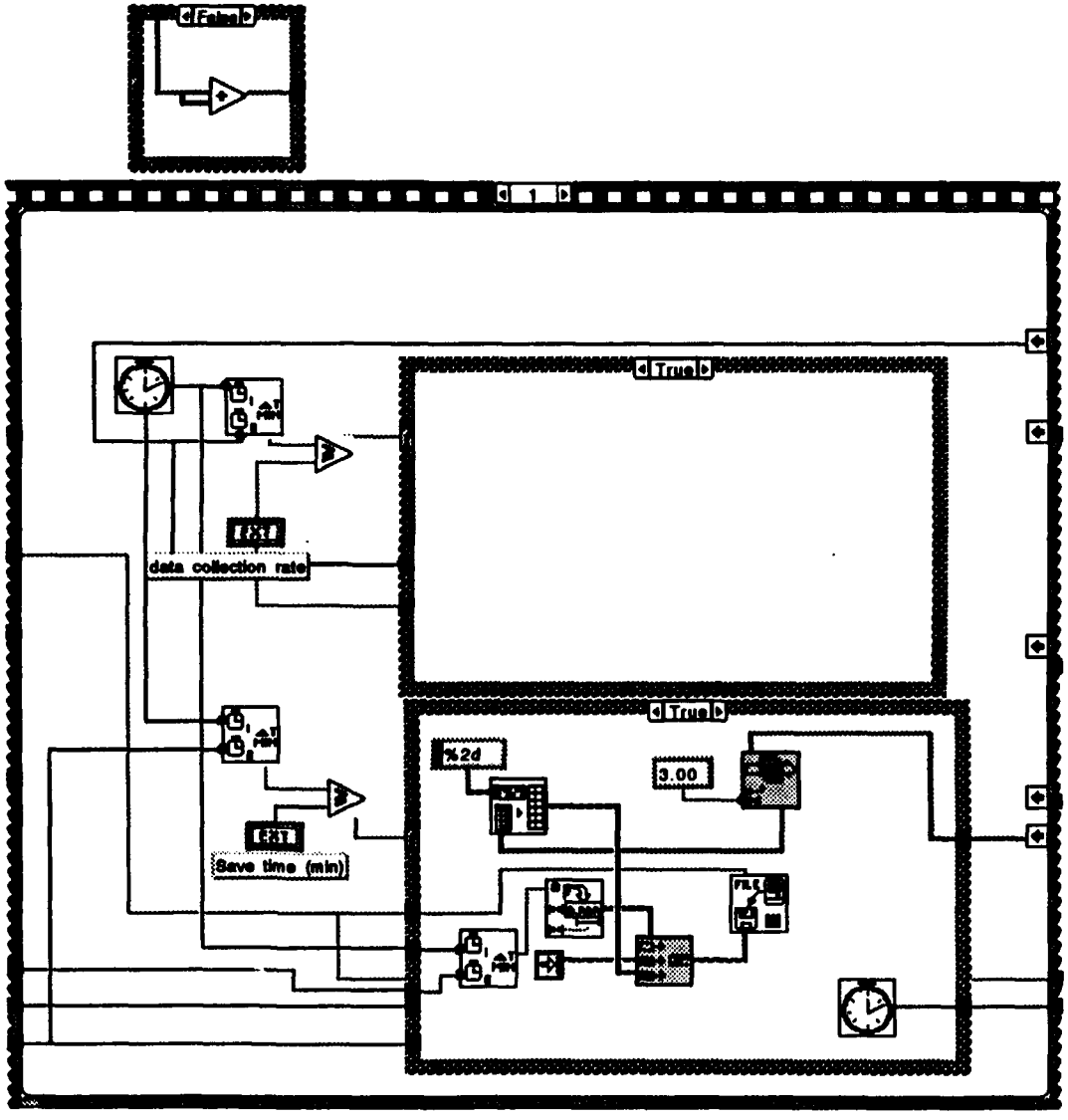
Block Diagrams for TCP02MMON and Read & Graph

Front Panel



Block Diagram

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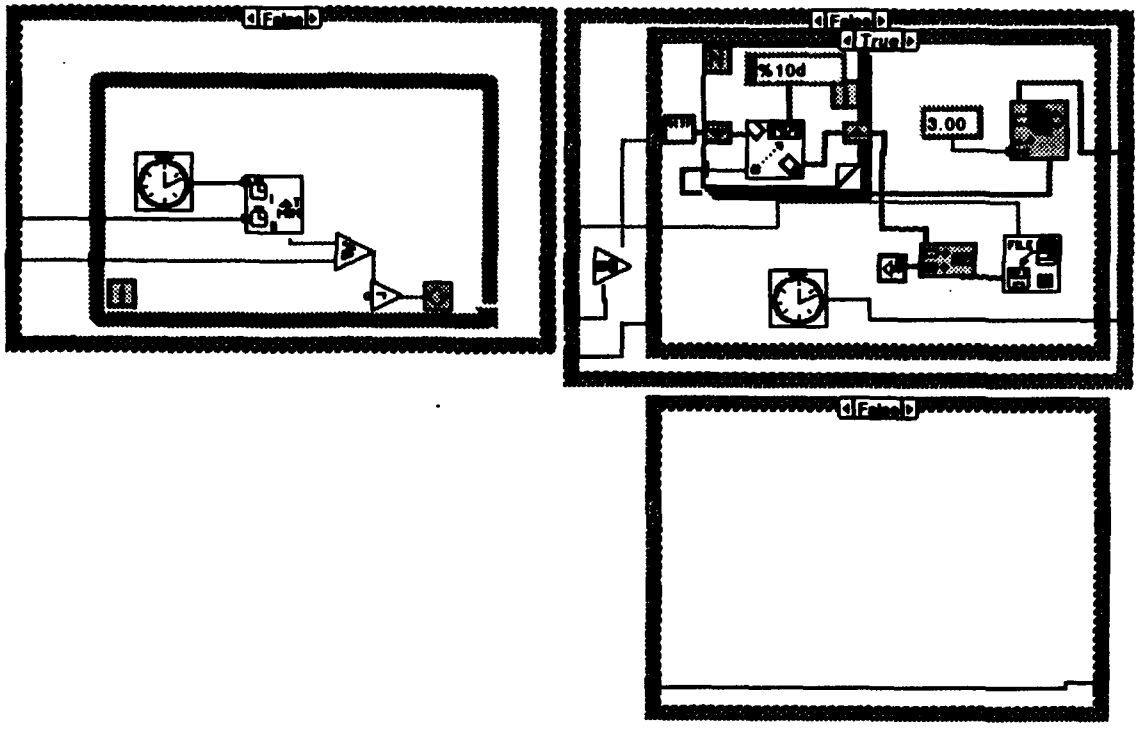
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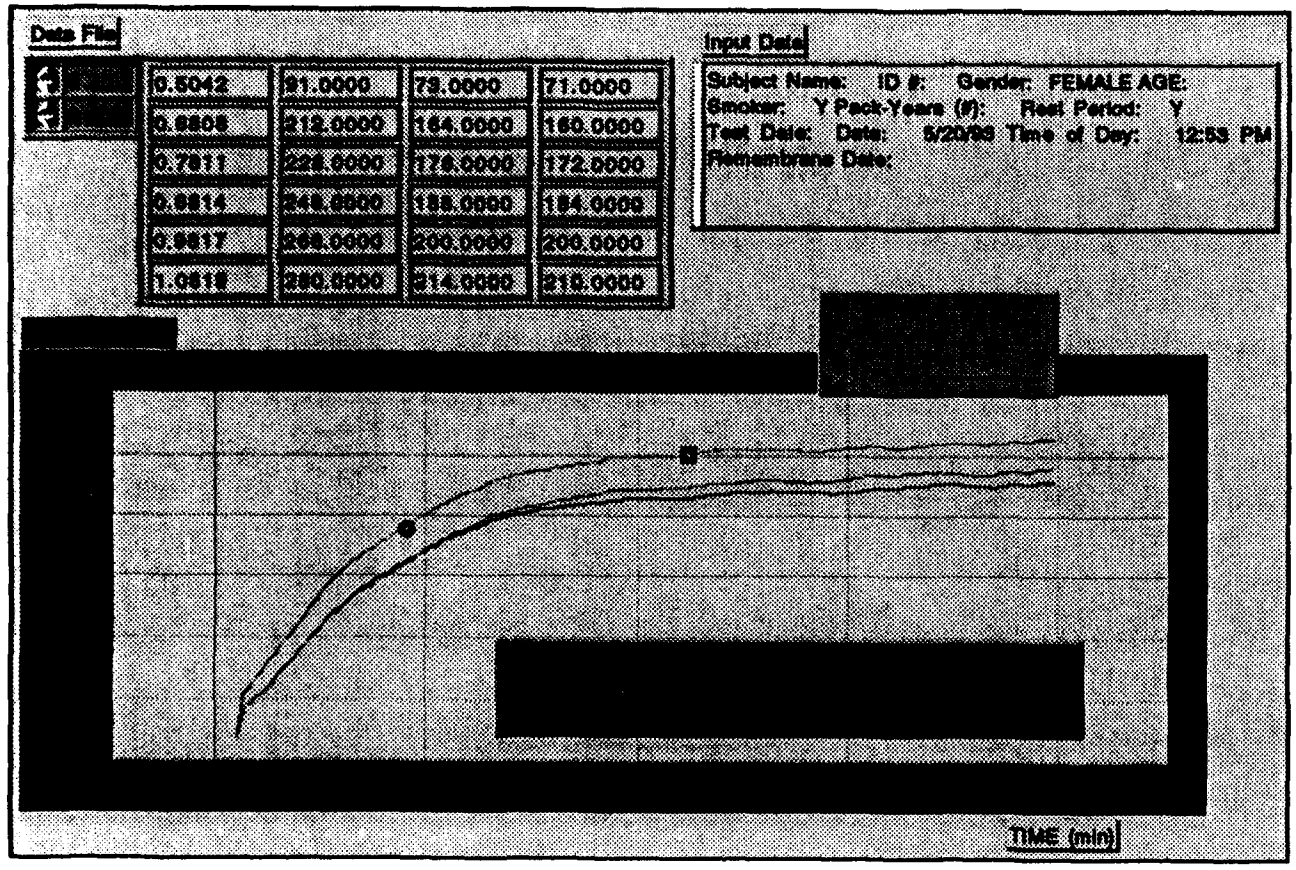
Front Panel



Block Diagram